Accurate error estimate in energy norm using a nearly-equilibrated kinematically-admissible displacement recovery technique

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Abstract

In this paper we present a displacement recovery technique for linear elasticity problems solved with the Finite Element Method (FEM). The enhanced displacement field provides a precise stress solution that can be used to obtain accurate estimates of the discretization error in energy norm using the Zienkiewicz and Zhu error estimator.

Previous works [1,2] aimed at developing an upper bound of the error in energy norm were based on a stress recovery technique that induced small lacks of equilibrium which have to be accounted for using correction terms. These terms required approximations of the exact displacement error and were obtained using projection techniques which leaded to a higher computational effort. This difficulty motivated the development of a displacement recovery technique to directly obtain an estimation of the exact displacement error, thus easing the evaluation of the correction terms.

The proposed procedure consists in a superconvergent patch recovery of the displacement field which considers the local fulfilment of boundary and internal equilibrium equations, Dirichlet constraints and, for singular problems, the splitting of the displacement and stress fields into singular and smooth parts. Furthermore, the recovered displacement solution can be projected to more refined meshes to obtain the initial displacements vector used by iterative solvers. This approach considerably reduces the number of iterations needed to reach the solution.

The method was validated by testing it with problems with exact solution and the numerical results show the high accuracy of the proposed technique for error estimation in energy norm.

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